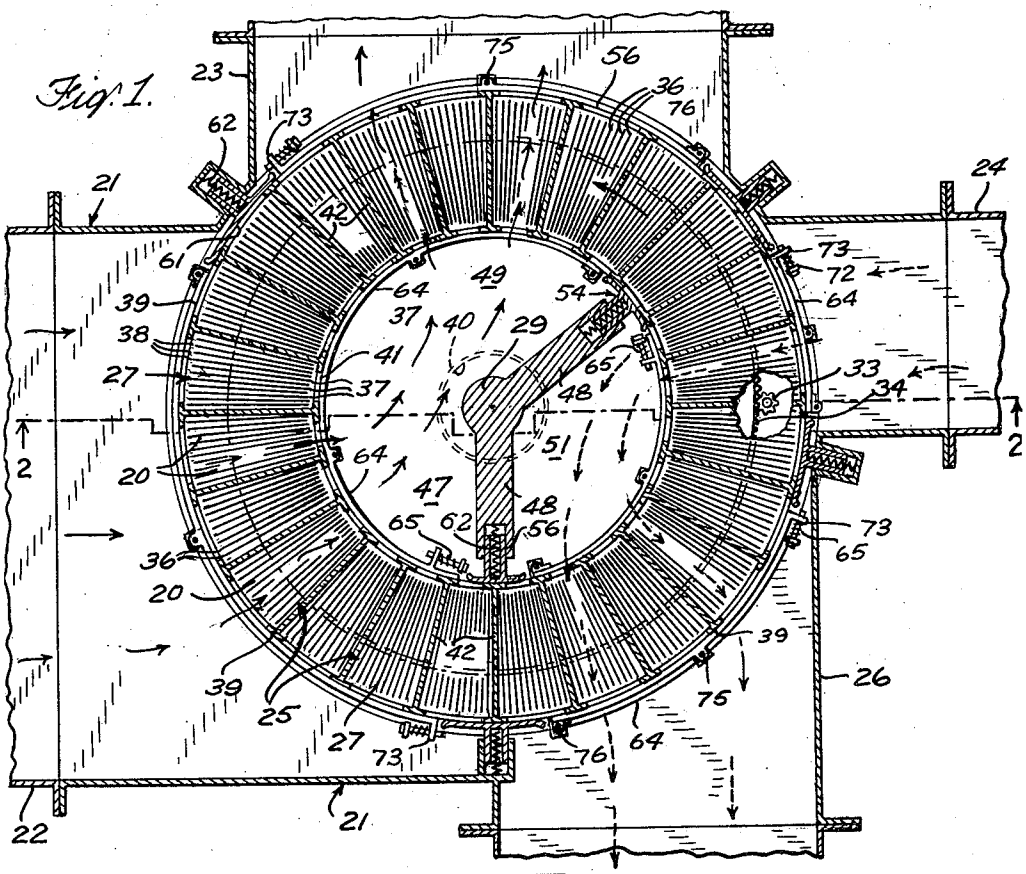
July 13, 1965 A. KOVATS 3,194,301

RADIAL FLOW ROTARY REGENERATIVE HEATER

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Fig. 1.



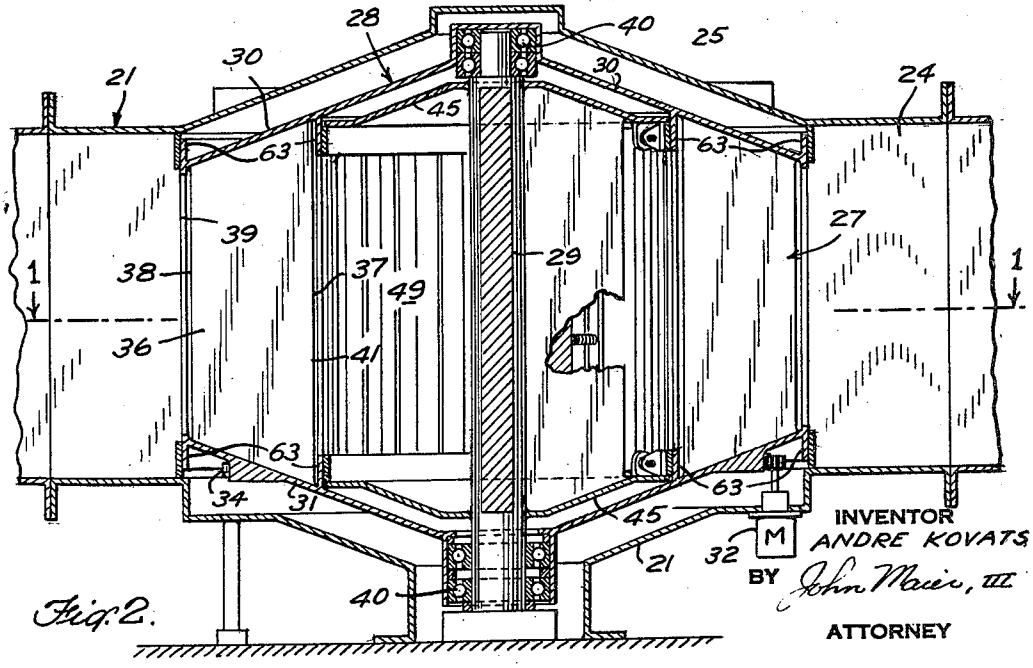


Fig. 2.

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Fig. 3.

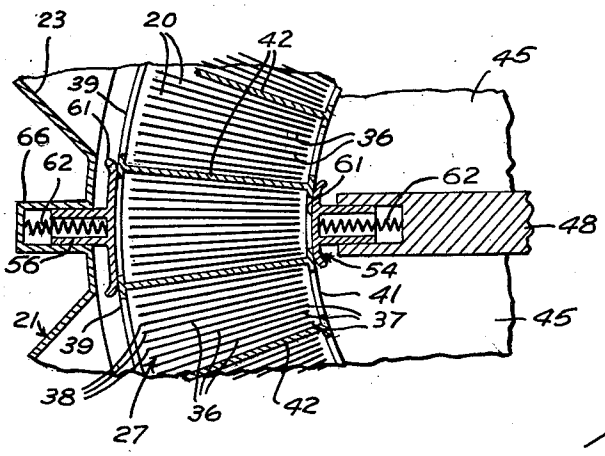


Fig. 4.

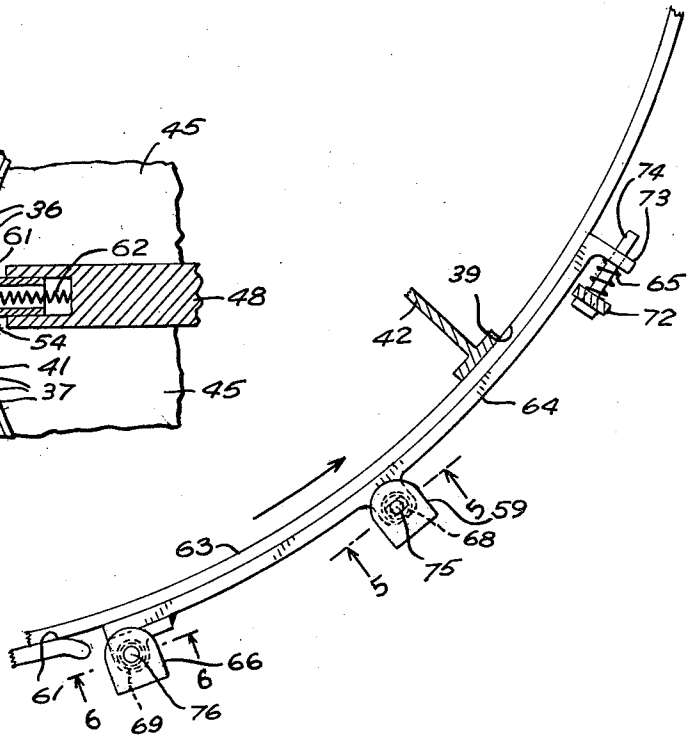


Fig. 6.

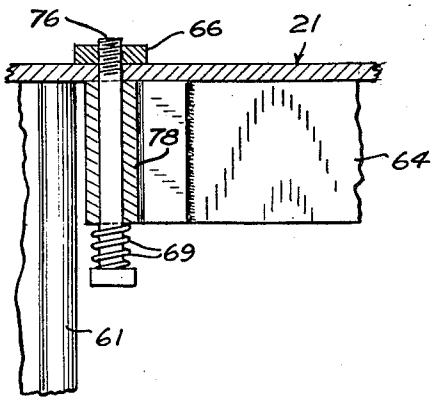
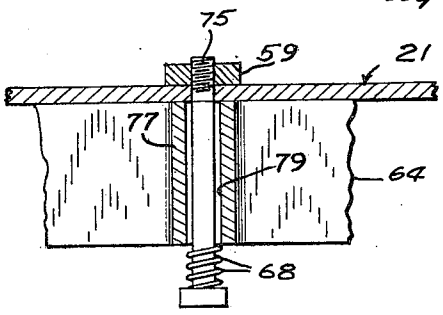


Fig. 5.



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3,194,301

RADIAL FLOW ROTARY REGENERATIVE HEATER

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Filed Nov. 27, 1963, Ser. No. 326,401
3 Claims. (Cl. 165—7)

This application is a continuation-in-part of U.S. patent application Serial No. 211,325, filed July 20, 1962, now abandoned.

This invention relates to preheaters and particularly to radial flow rotary regenerative preheaters.

In preheaters which are most commonly used for heating combustion air for use in a furnace with the flue gases from the furnace, it has been standard practice for the hot and cold fluids to be fed in and out of a rotating matrix to transfer heat from the hot fluid to the cold fluid. A cross-flow design is most commonly used in which the cold fluid is passed across one side of the matrix through a straight duct in one direction while the hot fluid is passed in the opposite direction through a straight duct across the other side of the matrix. As the matrix rotates about, the heat picked up by the matrix from the hot fluid is conveyed by the rotating matrix to the cold fluid. In preheaters prior to this invention, as far as is known, the inlet cross-sectional area and the outlet cross-sectional area of each of the ducts are equal. As is well-known, when a fluid is heated, it expands thereby increasing its specific volume. Likewise, when a gas is cooled, it contracts with a resulting decrease in specific volume. Obviously in a preheater, changes in the specific volume of both fluids is continuously taking place. The result of changing specific volumes of both the hot fluid and the cold fluid in preheaters prior to this invention has been that as the fluids pass through a preheater, the velocity of flow of the fluids is constantly changing. Such changes in velocity result in large energy losses requiring that the fans used to force the fluids through the preheaters have added capacity.

By way of this invention, the outer surface of a ring-shaped rotary matrix of a preheater can be divided into sectors representing equal arcs on the outside cylindrical surface. The same sectors result in equal arcs on the inside cylindrical surface. Obviously, the length of the arc on the inner surface is not as long as the arc on the outer surface, meaning that the sectors of the ring-shaped matrix converge toward the center of the cylindrical matrix. By diverging the top and bottom of the matrix toward the center, it is possible to compensate the decrease in dimension in one plane by an increase in dimension in the perpendicular plane, thereby maintaining a constant cross-sectional area of passageway through each section of the matrix. In this way, as the fluid flows through the matrix and into the inner chamber within the matrix, it flows through a passageway encompassing a number of sections, each section having a constant cross-sectional area from the outer surface to the inner surface. By passing the fluid back through the matrix at an angle rather than at a straight line, it is also possible to use either a larger number of sections on the matrix or a smaller number, thereby either increasing or decreasing the cross-section area through the matrix depending upon the change in specific volume of the fluid. In this way the area through which the fluid passes when it leaves the matrix may be made proportional to the change in specific volume of the fluid caused by the quantity of heat either added to a removal from the fluid. If the fluid is cooled, a smaller cross-sectional area is provided for the outlet pass through the matrix as compared to the inlet pass through the matrix. If the fluid is heated, a larger cross-sectional area is provided. In this way an approximately constant velocity flow is provided for the fluids resulting in reduced flow losses and increased efficiency.

Another source of loss in air preheaters has been the escape of fluids from around the matrix of the preheater. By means of circumferential seals and radial seals which expand and contract with the expansion and contraction and movement of the rotating air preheater, it is possible to overcome such losses.

It is therefore an object of this invention to provide a preheater of improved economy and efficiency.

It is another object of this invention to provide a preheater with approximately constant velocity of flow for each fluid passing through the preheater.

It is still another object of this invention to provide a preheater with minimum loss of fluids from around the matrix of the preheater.

It is still a further object of this invention to provide a preheater requiring minimum energy to force the fluids through the preheater.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a partly broken plan sectional view of a preheater embodying the present invention and taken along line 1—1 of FIGURE 2.

FIGURE 2 is a vertical section of a preheater taken along line 2—2 of FIGURE 1.

FIGURE 3 is an enlarged detail illustrating the relationship of a radial seal to the inner and outer surfaces of the revolving matrix.

FIGURE 4 is an enlarged detail illustrating means for engaging a circumferential seal.

FIGURE 5 is an enlarged cross-section taken along the lines 5—5 of FIGURE 4.

FIGURE 6 is an enlarged cross-section taken along the lines 6—6 of FIGURE 4.

Referring now the drawings and more particularly to FIGURE 1, the outside housing 21 has a first inlet port 22 which introduces a hot fluid such as flue gas from a source (not shown). A first outlet port 23 removes the flue gas after it has passed through the air preheater to a stock (not shown) or other suitable place for removal. A second inlet port 24 introduces a cold fluid such as combustion air from a source (not shown) to the preheater. Following the heating of the air, it passes through the second outlet port 26 for use for example in a furnace (not shown) or other device, requiring heated air. In a preheater of this type a matrix 27 is used to convey the heat from the hot fluid to the cold fluid. As best seen in FIGURE 2, the matrix 27 is supported by an interior shell 28. The interior shell 28 is mounted on a vertical post 29 by means of bearings 40 for rotation. A top 30 and bottom 31 of the interior shell 28 enclose the matrix at these levels. A motor 32 with a pinion 33 drives a ring gear 34 used to rotate the inner shell 28 and matrix 27 about the vertical axis of the post 29. During the rotation of the matrix 27, heat is extracted from the hot fluid and transferred to the cold fluid.

It is preferable to form the matrix 27 in sector portions 25. In this way a sector portion 25 can be inserted into the matrix 27 through an opening (not shown) in the top 30. The matrix 27 is designed in the form of a ring having an outer circumferential surface 39 and an inner circumferential surface 41. Preferably, the sector portions 25 are equivalent. Disposed within each sector 25 are regenerative elements 36. Each element 36 is placed radially relative to the axis of the post 29 and is composed of a material suitable for storing heat. Inner ends

37 of the regenerative elements 36 lie along the inner surface 41. Outer ends 38 of the regenerative elements 36 lie along the outer surface 39. The cross-sectional area formed by the two adjacent regenerative elements 36 and the top 30 and bottom 31 represents a separate passageway 20 for fluid flow.

In a plane perpendicular to the center line of the post 39, as is best shown in FIGURE 1, each sector portion 25 converges to a smaller and smaller distance at the inner surface 41. The sector portions 25 are radially enclosed by sheets 42. As is best shown in FIGURE 2, the top baffle 30 and bottom baffle 31 of the matrix 27, however, are conically formed so as to diverge farther and farther apart at the inner surface 41. In this way as each passageway 20 diverges in one plane to a smaller dimension, it converges in a perpendicular plane to a smaller dimension, thereby maintaining a constant total cross-sectional area at each point in each passageway 20. In this way, as a fluid passes through the matrix 27, there is no change in the velocity of flow.

As gases are cooled, they contract and increase in density and therefore have a smaller specific volume. When heated, gas expands thereby having a larger specific volume. If the same velocity of flow is to exist when a fluid is being removed from the matrix as when it is being introduced into the matrix, the cross-section area of a passageway for flow must be through the matrix 27 by changing the number of passageways 20 through the matrix 27 proportionately to the change in specific volume. As is shown in FIGURE 1, the cross-sectional area of the first inlet duct 22 and the passageway 20 associated therewith is substantially larger than the cross-sectional area of the first outlet duct 23 and the passageways 20 associated therewith. It is obvious, therefore, that the first inlet duct and the first outlet duct would be used for the hot fluid, such as flue gas. The hot flue gas would enter through the first inlet duct 22 which is comparatively large at the time when the flue gas has a very large specific volume and low density. The first inlet duct 22 is associated with a comparatively large number of passageways 20 through the matrix 27. As the flue gas passes through the passageways 20, it becomes cooled and reduces in specific volume. Due to the decrease in specific volume, a smaller cross-sectional area is required to remove the gases through the matrix at the same velocity with which they were introduced through the matrix. For this reason, the first outlet duct 23 also has a smaller cross-sectional area.

The second inlet duct 24, which introduces cool fluid into the preheater, has a smaller cross-sectional area than that of the second outlet duct 26 through which the heated fluid is discharged.

The sequence of inlet and outlet ducts here shown provides for a two-pass, counter-flow heat exchange relationship between the hot gas and the cold gas. The matrix 27 rotates from said second inlet to said first outlet, from said first outlet duct 23 to said first inlet duct 22, from said first inlet duct 22 to said second outlet duct 26 and from said second outlet duct 26 back to said first inlet duct 24.

Within the inner surface 41 of the matrix 27 is a chamber 47 which is divided by a partition 28 into a first compartment 49 and a second compartment 51. As best shown in FIGURE 2, plates 45 secured to shaft 29 provide sealing for the top and bottom of the axial chamber 47.

Radial seals 54, as best shown in FIGURES 1 and 3 are placed between the ends of the partition 48 and the inner surface 41 and between the outside housing 21 and matrix 27. The radial seals 54 used in association with the inner surface 41 prevent leakage about the partition 48 while the radial seals 54 is associated with an outer surface 39 of the matrix 27 prevent leakage between two adjacent ducts. Curved surfaces 61 with sliding protrusions 56 are provided on the radial seals 54 for sliding association with the matrix 27. The shape of the surface 61 depends on whether the surface 61 contacts the inner surface 41 or the outer surface 39 of the matrix 27. Springs 62 held within channels 55 force the surface 61 against the matrix. The springs 62 provide force for a positive seal while still providing sufficient elasticity to compensate for expansion and contraction and irregularities in the matrix 27. It is to be understood, however, that other types of elastic seals are equally as suitable.

Circumferential lips 63 which protude from the top 30 and the bottom 31 of the shell 28 are in sliding contact with circumferential seals 64. The circumferential seals 64 are held in sliding contact with the lip 63 by means of springs 65 (FIG. 4) reaching between fixed bar 72 and extension 73. The fixed bar 72 is secured to the housing 21. The spring 65 is mounted on rod 74 which slideably engages extension 73. The circumferential seals 64 as shown in FIGURE 4 are held against the outside housing 21 by springs 68 and 69. The rod 75 is threaded to the bracket 59 and the rod 76 is threaded to the bracket 66. An extension 77 on the seal 64 has an enlarged slot 79 to permit tangential movement of the seal 64. The rod 76 is journaled in extension 78. The spring 68 (FIG. 5) forces the seal 64 against the housing 21 by acting against the fixed rod 75 and the extension 77. The spring 69 (FIG. 6) forces the seal 64 against the housing 21 by reacting against the rod 76 and the extension 78. The circumferential seals 64 used on the inside of the matrix 27 operating similar to those on the outside except that they are pressed against the plates 45 rather than against the housing 21 and are oppositely curved to conform to an inner cylindrical surface.

Although the invention has been described with a certain degree of particularly, it is understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. A regenerative preheater for the exchange of heat between a first fluid and a second fluid comprising:

a ring-shaped permeable matrix having an inner surface and an outer surface with equally-spaced regenerative elements radially placed between said surfaces so as to form a radial passageway between said elements, said elements being divergently shaped so that the cross-sectional area of the passageway between two contiguous regenerative elements remains approximately constant as the elements radially converge,

enclosing means for preventing the escape of fluid to the outside atmosphere, said enclosing means including radial seals and circumferential seals,

a shaft supporting said matrix,

a partition within the space defined by said inner surface for separating said space into a first compartment and a second compartment,

a first inlet duct defining a cross-sectional area of passageway radially inward for introducing a first fluid through said matrix into said first compartment,

a first outlet duct defining a cross-sectional area of passageway radially outward for removing said first fluid through said matrix from said first compartment,

a second inlet duct defining a cross-sectional area of passageway radially inward for introducing a second fluid through said matrix into said second compartment,

a second outlet duct defining a cross-sectional area of passageway radially outward for removing said second fluid through said matrix from said second compartment, and

means for continuously rotating said matrix about said supporting shaft so that said matrix passes from the inlet of one fluid to the outlet of the other fluid.

2. A regenerative preheater for the exchange of heat between a hot fluid and a cold fluid comprising:

a ring-shaped permeable matrix having an inner surface and an outer surface with equally-spaced regenerative elements radially placed between said surfaces so as to form a radial passageway between said elements, said elements being divergently shaped so that the cross-sectional area of the passageway between two contiguous regenerative elements remains approximately constant as the elements radially converge,

an outside housing surrounding said matrix,

a shaft supporting said matrix,

a partition within the space defined by said inner surface for separating said space into a first compartment and a second compartment,

a first inlet duct defining a cross-sectional area of passageway radially inward for introducing a hot fluid through said matrix into said first compartment,

a first outlet duct defining a cross-sectional area of passageway radially outward for removing the hot fluid through said matrix from said first compartment, the first outlet cross-sectional area being sufficiently smaller than the first inlet cross-sectional area to compensate for the decrease in specific volume of the hot fluid caused by the cooling effect of the matrix,

a second inlet duct defining a cross-sectional area of passageway radially inward for introducing a cold fluid through said matrix into said second compartment,

a second outlet duct defining a cross-sectional area of passageway radially outward for removing the cold fluid from said second compartment through said matrix, the second outlet cross-sectional area being sufficiently larger than the second inlet cross-sectional area to compensate for the increase in specific volume of the cold fluid caused by the heating effect of the matrix,

an inner housing enclosing the top and bottom of said rotating matrix, said inner housing having inner and outer sealing lips,

plates enclosing the top and bottom of the space defined by the inner surface of said matrix,

outside radial seals located between each duct to prevent leakage around the matrix within said outside housing,

inside radial seals located at the ends of said partition to prevent leakage about said partition,

inner circumferential seals including bands in sliding relation with said inner sealing lips,

springs for forcing said inner circumferential seals against said lip,

springs for forcing said inner circumferential seals against said enclosing plates,

outside circumferential seals including bands in sliding relation with said outside sealing lips,

springs for forcing said bands against said outside sealings lips,

springs for forcing said outside circumferential seals against said outside housing, and

means for continuously rotating said matrix about said supporting shaft in a direction from said second inlet to said first outlet, from said first outlet to said first inlet, from said first inlet to said second outlet, and from said second outlet back to said first inlet.

3. A regenerative preheater according to claim 2 wherein:

the first inlet duct and first outlet duct are at an angle to one another and the second inlet duct and second outlet duct are at an angle to one another.

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